surface wave resonance frequency, the plasma density information can be obtained by simply calculating electron density n_e in plasma which is substantially equivalent to the plasma density.

Subsequently, a concrete plasma density information measuring example by a plasma density information measuring apparatus of the present embodiment will be explained.

Atmosphere of the space S in the chamber 1 was adjusted to be argon 10m Torr. Then, high-frequency power of 13.56 MHz was applied to the ignition electrode from the high-frequency electric source 8 at the output amount of 1.2 kW, thereby generating reactive plasma PM in the space S.

The tube 14 of the measuring probe 12 is a Pyrex glass tube having outer diameter of 6 mm and dielectric constant of 4. The coaxial cable 16 is a semi-rigid cable of 50Ω, and the conductor piece 17 is made of aluminum foil.

First, as shown in Fig. 2, the measuring probe 12 was set such that the length L between the base end of the loop antenna 15 and the tip end of the tube 14 became 3.5 mm. Then, high-frequency power of 10 mW from 100 kHz to 3 GHz was output from the high-frequency oscillator 18 while conducting swept-frequency. The reflection amount of the high-frequency power at that time was detected by the directional coupler 19, and the counter frequency variation of a reflection coefficient of high-frequency power was measured and displayed on the display monitor 23 as shown with the uppermost curved line Ra in Fig. 6.

Subsequently, as shown in Fig. 5, the set position of the measuring probe 12 was changed such that the length L between the base end of the loop antenna 15 and the tip end of the tube 14 became 5.5 mm, 7.5 mm, 9.5 mm, 11.5 mm and 13.5 mm. At each of the positions, the counter frequency variation of a reflection coefficient of high-

frequency power was measured and displayed as the above case. The results are as shown with curved lines Rb to Rf in Fig. 6.

The curved lines Ra to Rf show some absorption peaks Pa to Pd indicative of strong absorption of the high-frequency plasma density information at the plasma load side. The frequency in the absorption peaks Pa to Pd is plasma absorption frequency. It is possible to grasp the characteristics of the generated plasma PM from the plasma absorption frequency. However, only the absorption peak Pa of the lowest frequency appears in a position of substantially constant frequency (1.5 GHz) even if the tip end length L is varied as shown in Fig. 7, and the same plasma absorption frequency is measured always. Namely, the plasma absorption frequency which does not depend on the tip end length L is plasma surface wave resonance frequency f ($=\omega/2\pi$). Even an absorption peak which appears at the lowest frequency side, if its frequency is varied when the tip end length L is varied, such an absorption peak is not the plasma surface wave resonance frequency. That is, in the present embodiment, the tip end length L is varied so as to check whether the absorption peak which appears at the lowest frequency side is plasma surface wave resonance frequency.

If the plasma surface wave resonance frequency f is obtained, electron plasma angle frequency ω_p is obtained based on the above-mentioned expression as follows:

$$\omega_p = \omega \times \sqrt{(1+\varepsilon)} = 2\pi \times 1.5 \times 10^9 \times \sqrt{(1+4)} = 3.35 \times 10^9$$

Further, electron density n_e of plasma PM is obtained as follows:

$$n_e = e_o \cdot m_e \cdot \omega_p/e = 1.4 \times 10^{11}/cm^3$$

Since the electron density n_e of the plasma PM is substantially equivalent to the plasma density, it is easy to grasp (monitor) the characteristics of the generated plasma PM.

In the case of the present embodiment, since the tube is interposed between the plasma PM and the loop antenna 15 as well as the coaxial cable 16, a foreign object should not enter the plasma PM from the loop antenna 15 and the coaxial cable 16, and the clean state of the plasma can be secured. Further, because the tube 14 is interposed, the loop antenna 15 and the coaxial cable 16 are prevented from being damaged by the plasma PM. Furthermore, during the measurement, even if stains comprising insulative films are thinly adhered on the surface of the tube 14, since the insulative film is dielectric, the measuring system is not changed substantially, and variation is not caused in the measured result due to the stains of insulative film. Therefore, it is possible to measure the plasma density information over the long term.

Further, this method is carried out only by supplying the high-frequency power from the loop antenna 15 through the tube 14 to grasp the absorption phenomenon of the resonance high-frequency power which is easily measured. Therefore, plasma density information can be measured extremely easily. Furthermore, hot filament is not used, there is no need to be worried about atmosphere contamination by evaporated tungsten, and it is unnecessary to exchange the hot filament.

When it is necessary to measure plasma density information at another position in plasma PM, the insertion length (shown with M in Fig. 1) of the measuring probe 12 into the chamber 1 may be changed to the other position, and the measurement may be carried out in the same manner as that described above. By measuring the plasma densities at a plurality of positions, it is possible to grasp the distribution of plasma density.

The present invention should not be limited to the above-described embodiment, and can be modified and carried out as follows:

(1) Although the coaxial cable 16 provided at its tip end with the loop